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An Application to the Wave Actuated Swing-type Permanent Magnet Motor

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ABSTRACT

An application in the permanent magnet (PM) driving motor with magnetic energy and natural energy of wave is presented. The study is developed by using the small scaled prototype application of wave actuated swing-type device. The wave actuated swing-type PM driving motor consists of an supporter frame base, a rotator module, a stator module, a gear module and the wave actuated swing-type device. The swing motion is supplied from the natural energy provided by the wave actuated swing-type device. The wave actuated swing-type PM driving motor can rotate with magnetic energy and natural energy of wave swing motion. The wave actuated swing-type PM driving motor would be considered as a new technique in the field of green energies. In the future, it would be designed into a generator to produce the electric power.

Keywords: application, swing-type, PM, motor, wave

1. INTRODUCTION

There are many sustainable, renewable energies already used in the engineering fields of motor, energy and power. Typically by using the energy transition from the natural energy into the mechanical energy. The natural energy used in many pattern and series of green energy e.g. wind energy, hydro energy, tidal energy, solar energy and geothermal energy. The mechanical energy used in many devices of mechanism and plant e.g. vehicle and power plant. Under the impact effects of global warming and greenhouse, reducing energy and carbon consumption is an urgent issue to save the earth and make a better good place. Early electrical generator directly driven with traditional motors by electrical power has the problem of large power consumption. Recently, there are some power saving improvement in the motors driven by diesel fuel. In 2019, Mobarra et al. presented the experimental analysis to reduce the diesel fuel consumption with a rotating-mode stator for the permanent magnet synchronous generator (PMSG). In 2015, Alshehry and Belloumi presented the power plant invested by using of renewable energy sources is an urgent necessity to have the good control for fossil fuel consumption and carbon dioxide (CO2) emissions. In 2019, Elgamal et al. presented the numerical modeling of commercial virtual power plants (CVPPs) for the operational renewable energy plants in Scotland to provide

higher profits. The background/motivation of this presented paper is to develop a related application in the fields of sustainable and renewable energies.

Conventionally, the permanent magnet (PM) motor is rotating by the power supplied of direct current (DC) electricity, with magnet to instead of the windings in the fields of armature, for the good of less heat, more efficient and less power consumption than the alternative current (AC) induction motor. In 2019, by Wikipedia, the free encyclopedia, there are some type of PM electric motors used in the application of vehicle fields, e.g. the Chevy Bolt, the Chevy Volt and the Tesla Model 3. There are some type of control applications for PM synchronous motor (PMSM) to accelerate the torque response. In 2020, Mesloub et al. presented the direct torque control (DTC) by using space vector modulation (SVM) scheme for the PMSM. In 2019, Ye presented the control scheme based on the iterative flux sliding-mode observer (IFSMO) method for the PMSM. The torque is provided from the reactions of circumference in the conventional winding fields of armature, thus the direction of current usually changed many times in one rotation of shaft to maintain torque continuously. In 2016, Ellabban and Abu-Rub presented the advantages and disadvantages of the Z-source converter (ZSC) improvement types used for DC/AC converters in the general traditional motor drive. More literature survey of this presented paper in related to the fields of sustainable, renewable energies and PM motors are listed as follows. There are some serious environment problem produced by the fossil fuel driven automobiles, one of the issue solving is to develop the sustainable electric motor, it is presented electric vehicle by Pradhan and Patil in 2016. The green energy e.g. wind energy is a popular use, Shahat and Shewy in 2009 presented the performance improvement of PMSMs for this applications. A special issue of field-modulated permanent-magnet (FMPM) machine is presented and studied in the electric machines and drives for renewable energy harvesting by Li et al. in 2016. The PM motors are used in the hybrid/electric vehicle ((H)EV) and the sustainability of PM materials are studied by Bailey et al. in 2017. The renewable energy and climate change on the impacts of environmental and health are reviewed and studied by Owusu and Asumadu-Sarkodie in 2016. In 2020, Alves Dias et al. presented the supply discussions of critical raw materials in the European Commission, the rare earth material elements are used to manufacture the PM, then for the application of wind turbine generators and EV motors.

The above is the electrical controller usage in the PM motor and traditional motor. In 2019, Hong and Tsai presented a small scaled prototype application of rotating arms type PM motor without any wirings. In 2019, Hong has improved the small scaled prototype work of PM motor with an electrical controlled swing-type device to help and control the complete rotation smoothly. The motivation of this application is to complete the whole continuously rotation of motors (energy output) by using the natural energy (energy input) without any electrical controller. The inventor of this invention upholds many years of experience in the design, development and actual production of the related PM for the further application in the natural energy. The natural wave always living and running in the ocean, lake and river. The upward and downward of moving wave can produce wave energy, it could be transformed into mechanical energy by the proper operation and derives. It is a small scaled prototype objective of the invention to provide a wave actuated swing-type PM driving motor which is different from the conventional armature motors in structure and utilizes the principle of magnetism. The invention has a wide range of applications, e.g. to rotate the generator to produce the electric power. More studies of applications can be applied into the field of green energies, more good conditions would be improved in the environment protections. The wave actuated swing-type PM driving motor would be considered as a new technique in the field of green energies. It is the purpose of this study to design a possible prototype for this wave actuated swing-type PM motor. Owing to the ocean wave occurs every time, so the wave energy provides all the time. It would be friendly for the environment and available for the people to use the natural energy as an input energy to design a wave actuated swing-type PM motor.

2. DESIGN AND CONSTRUCTION

It is an improved design of the wave actuated swing-type PM driving motor developed as shown in Fig. 1 which is an another improvement for the electrical controlled swing-type PM driving motor provided by Hong in 2019. In the similarly way for the input energy, the electrical controlled swing-type module is replaced by the wave actuated swing-type module. The wave actuated swing-type PM driving motor comprises a supporter frame base, a rotator module, a stator module, a gear module and wave actuated swing-type device. The supporter frame base provides the shaft support for rotating shaft, swing shaft and wave actuated swing-type device. The location of wave, float ball and gear in the wave actuated swing-type device are shown in Fig. 2. The moving of wave is allowed to have the upward and downward move of float ball, using steel rod connected to the gear module in swing motion and locate at the side of rotating shaft end. The rotator module comprising two PM rotators, fan and a fan central bracket is also provided by Hong in 2019. The swing motion as an input energy is supplied from the natural energy provided by the wave actuated swing-type device.

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It is used three dimensional (3D) printer to built the most parts of the small scaled prototype application for the wave actuated swing-type PM driving motor. The wave actuated swing-type device provided with the water wave, a float ball, an active gear, a passive gear, a swing shaft and a supporter that are also shown in Fig. 2. The active gear is rigidly connected with float ball by a steel rod. The gear modular ratio is defined as follows,

$$mr = dp / ga, \quad (1)$$

where mr is gear modular ratio, dp is diameter of the pitch circle, ga is gear amount. The gear modular ratio is 1.5 used for the gear module, e.g. for big active gear, the diameter of the pitch circle is 70.5mm and gear amount is 47.

The rotational motion would be produced and described as follows for the wave actuated swing-type PM driving motor in the similarly way by noting the electrical controlled swing-type module provided by Hong in 2019, which is replaced by the wave actuated swing-type module. As we know that PM stator ring piece is disposed between the swing shaft supporter and the rotating shaft supporter, PM rotator ring piece on the rotating fan central bracket is disposed between the PM stator and the rotating shaft supporter. The sinusoidal forms of incoming water wave move the float boat to go upward and downward. The upward and downward motion pass through the steel rod to move the active gear undergoing of swinging forward and backward. Thus, water wave power drives the wave actuated swing-type device to rotate the active gear in swinging forward and backward. The PM rotator of the fan central bracket would generate a torque then rotate the rotating shaft.

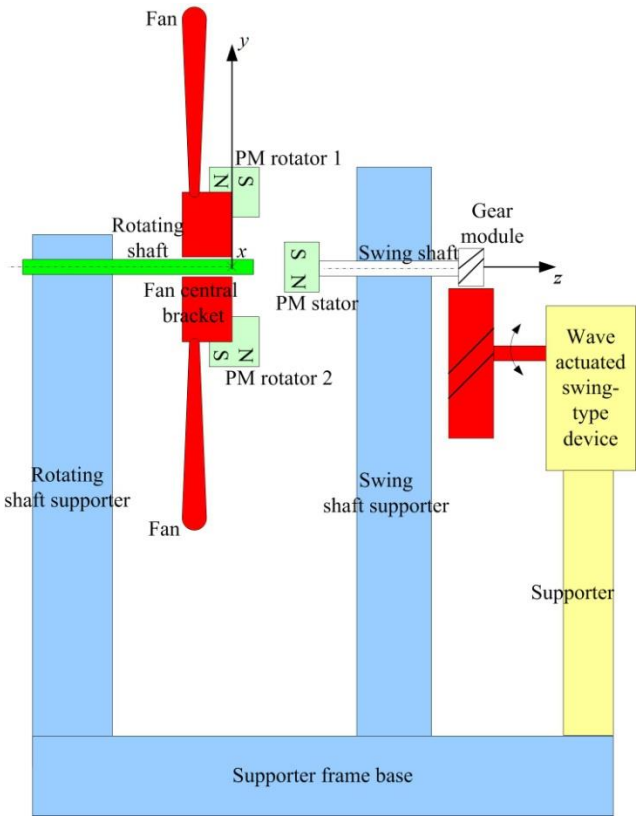

Figure 1 Improved installation of a wave actuated swing-type PM driving motor

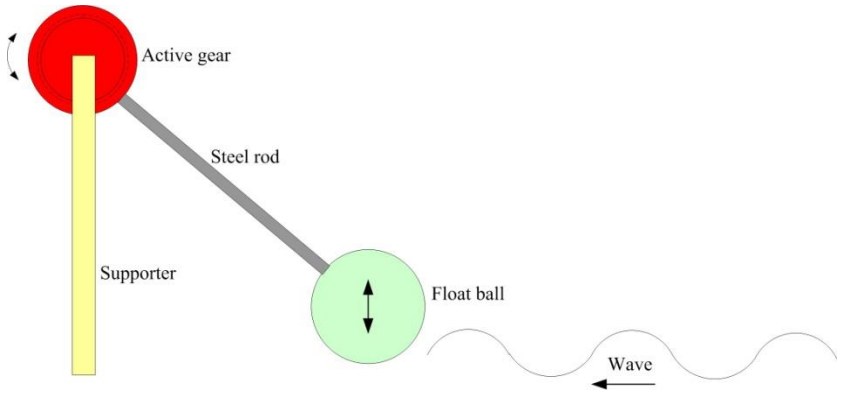

Figure 2 Location of wave, float ball and gear in the wave actuated swing-type device

3. RESULTS AND DISCUSSION

It was claimed that in this paper did not use any international standard tests for the experimentation, only used personal investigation view to find the preliminary data. The small scaled prototype of the wave actuated swing-type PM driving motor is shown in the Fig. 3, there are some parts including float ball, steel rod, supporter, active gear, passive gear, PM stator, PM rotator 1, PM rotator 2 and fan central bracket. Same dimensions for PM rotator 1 and PM rotator 2 are used and embedded in the fan central bracket. The PM stator are placed at the end side of rotating shaft. The dimensions of most parts in the small scaled prototype are listed in Table 1.

Table 1 Dimensions of most parts in the small scaled prototype

Parts	Arc length	Height	Thickness
PM rotators	30mm	10mm	2mm
PM stator	11mm	10mm	2mm
	Gear form	Amount of gear	Pitch circle diameter
Active gear	big	47	70.5mm
Passive gear	small	10	15mm
	Bracket diameter	Shaft hole diameter	Bracket height
Fan central bracket	35mm	5.2mm	25mm
	Length	Height	Thickness
Fan	33mm	30mm	0.9mm
	Length	Diameter	
Steel rod	150mm	5mm	
	Diameter	Thickness	
Float ball	100mm	1mm	

For the description of the small scaled prototype operation, firstly needed the float boat to go upward and downward, secondly rotate the gear module in swinging forward and backward, simultaneously rotate the PM stator in swinging forward and backward, finally rotate the fan in completely rotations. For the theoretical results of the small scaled prototype, when the proper sinusoidal forms of incoming water wave move the float boat to go upward and downward, e.g. the theoretical data for the rotating shaft rotation speed (rpm) would be obtained and shown in Fig. 4, the rotation speed of rotating shaft is increasing with the upward and downward float boat movement speed (mm/s). For the experimental tests of full scaled prototype in the natural wave would be ran in the future with a water channel to provide the sinusoidal forms of incoming water wave, thus move the float boat to go upward and downward properly.

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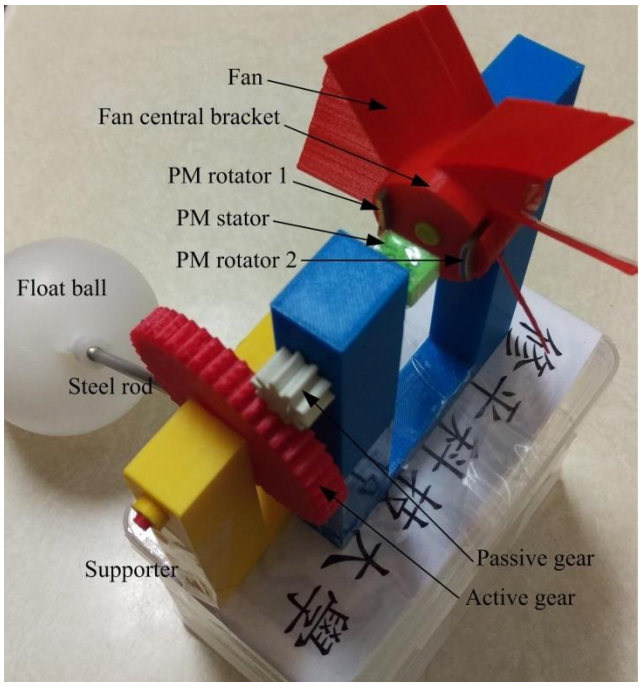

Figure 3 Small scaled prototype of the wave actuated swing-type PM driving motor

The theoretical data in small scaled prototype for the rotating shaft rotation speed (rpm) can be provided only as a preliminary reference used in the future studies. The full scaled prototype would be designed and provided in the safe condition for that ocean wave is very dangerous to use. The safety first for person is always considered when this application is applied. The ocean wave would safely move the float boat to go upward and downward above the water level. The float boat can always move upward and downward owing to the ocean wave occurs every time and the wave energy provides all the time to provide as an input energy to rotate the wave actuated swing-type PM motor. More studies of applications can be applied into the field of green energies, more good conditions would be improved in the environment protections. The wave actuated swing-type PM driving motor would be considered as a new technique in the field of green energies. In the future, it would be interesting to design a suitable wave channel for providing a stable upward and downward wave. Also, the wave actuated swing-type PM motor would be designed into a generator to produce the electric power.

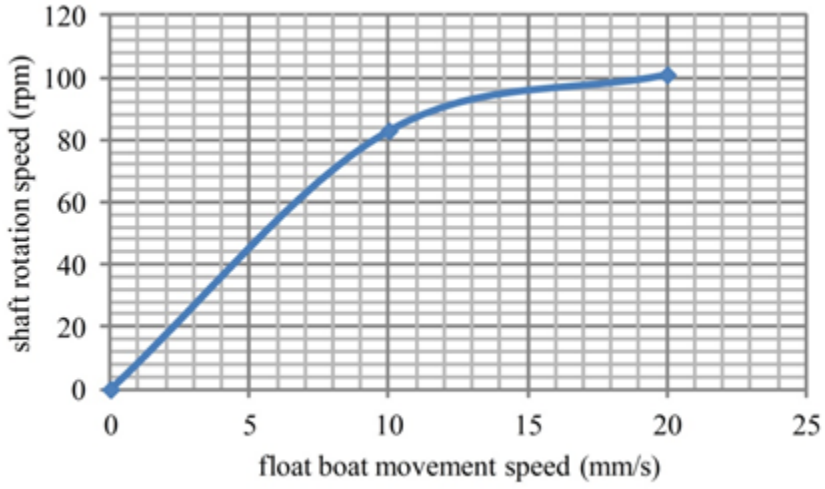

Figure 4 The rotating shaft rotation speed (rpm) vs. float boat movement speed (mm/s)

4. CONCLUSIONS

The completion of this application was referred to the invention patient I667408 of Taiwan, ROC, by C.C. Hong in 2019. Right now, the 3D printer is used to built the most parts of the small scaled prototype for the wave actuated swing-type PM driving motor. The

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theoretical data in small scaled prototype for the wave actuated swing-type PM driving motor is provided as a preliminary reference. The full scaled prototype for the wave actuated swing-type PM driving motor would be improved and provided in the factory if possible. The wave actuated swing-type PM driving motor would contribute to the green energy technique in the future by using the nature energy of water wave. Also, the actuated swing-type PM driving motor would be designed into a generator to produce the electric power.

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This study has not received any external funding.

Conflict of Interest

The author declares that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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